

# COMBUSTION EFFICIENCY AND EMISSIONS R&D

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## ABSTRACT

The Department of Energy's Office of Transportation Technologies funds Sandia National Laboratories/California to serve as the technical program coordinator for combustion efficiency and emissions R&D conducted at U.S. universities in the engine combustion area. University principal investigators work closely with representatives of the U.S. auto industry in two areas: (1) Fuel/combustion system optimization and (2) Cylinder design for reduced emissions. This report summarizes the projects ongoing at the universities in support of the DOE/OTT mission.

## INTRODUCTION

Over the past year a competitive procurement was conducted and four new university contracts (Drexel University, Massachusetts Institute of Technology, Pennsylvania State University, and the University of Illinois) were awarded. Each project area is described and includes a table identifying the individual participants and their specific project titles. The universities conduct fundamental research that provides the technical foundation for understanding test results obtained in the auto company laboratories. Technical discussions are held on a regular basis (at least biannually) to enable timely feedback of information between the DOE-funded efforts and the needs of the auto industry. Details of each individual project can be obtained during the poster presentation.

### Fuel/combustion system optimization

The objective of this work is to conduct research that will lead to a characterization and optimization of fuel delivery into the cylinder of an automobile engine. Optimized air/fuel mixture quality is critical to engine performance, efficiency, and emissions. This is particularly true during cold start and, to a lesser degree, warm transients. There is work currently underway within the automotive industry to characterize the port injection process in steady-state flow rigs, including measurements of spray pattern and footprint, droplet size, and droplet velocity. These characterizations are then used to seek correlations with engine performance measurements obtained on dynamometer test stands. The work in the university projects seeks to provide fundamental information and insight to test results from the engine companies. Of particular emphasis is the determination of the relationship between port- and direct-injection processes and the air/fuel distribution in the combustion chamber at the time of ignition.

Lab/University	Principal Investigator	Project Title
Florida A&M	Joseph Johnson	Turbulent Measurements in Fuel Injection Emulation
Mass. Inst. of Tech.	Simone Hochgreb	Experimental Investigation of the Fuel Distribution in Gasoline DI Engines

Princeton University	Fred Bracco	Multi Dimensional Measurements and Computations of Engine Flows and Combustion
Univ. of Illinois	James Peters	Fuel/Air Mixing in a Spark Ignition Engine

### **Cylinder design for reduced emissions**

The objective of this program area is to conduct fundamental research to characterize the in-cylinder processes leading to hydrocarbon emissions and post-combustion oxidation. This work is being conducted because the automobile industry faces more stringent regulations in the coming years due to mandated limits in permitted levels of emissions of a wide range of hydrocarbon and partially-oxidized, hydrocarbon species. Meeting these emission levels may require significant improvements in automobile engines and modifications in the composition of the gasoline fuels burned. These advances in the engine and fuels technologies will require a great deal of research and development effort.

The primary source of unburned hydrocarbon species emitted from engines is due to fuel and air trapped in confined volumes in the combustion chamber, particularly the ring crevice between the piston and the cylinder wall. In this confined volume, heat transfer to cylinder and piston surfaces cools the gases and impedes their consumption by flame propagation. After normal flame propagation is complete, these gases escape from the crevices, mix with combustion products, are partially burned and then leave the combustion chamber along with the exhaust gas. Other sources of unburned hydrocarbons include fuel adsorbed by oil layers and deposits on the interior surfaces of the cylinder, regions of dilute mixture where the oxidation reactions are slow, and boundary layers near cool surfaces where heat transfer can cool the gases, reducing the reaction rates.

Lab/University	Principal Investigator	Project Title
Drexel University	Nick Cernansky	Post-Combustion Oxidation of Hydrocarbons
Penn State University	Dom Santavicca	An In-Cylinder Study of UHC Formation in Port-Injected Spark-Ignition Engines Under Cold-Start Conditions